# PART 3

# LEVEL 1 MODELS

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## Chapter 1. MICHTOX PCB Model Executive Summary

MICHTOX is a toxic chemical mass balance and food chain bioaccumulation model. In this project, the model was used to provide a screening-level analysis of the potential future trends in total polychlorinated biphenyl (PCB) concentrations in Lake Michigan water, sediment, and fish under a variety of contaminant load scenarios. The model also provided a comparison of an older, "off-the-shelf" model with the more complex models developed as part of the Lake Michigan Mass Balance Project (LMMBP). Results of the MICHTOX modeling indicate that atmospheric exchange is a dominant loss process of total PCBs in Lake Michigan, and that the reservoir of total PCBs in the sediment has a significant impact on the future trends in concentrations of total PCBs in lake trout.

MICHTOX was developed in the early 1990s to provide guidance for the Lake Michigan Lake-wide Management Plan (LaMP) and to assist with the planning of the LMMBP (Endicott *et al.*, 2005). During the early part of the LMMBP, MICHTOX was updated and used as a preliminary assessment tool of the LMMBP PCB data (Endicott, 2005). For the present study, the updated fate and transport submodel was used to provide exposure concentrations to the food chain submodel under

seven scenarios of future PCB loadings to Lake Michigan.

Chapter 3 summarizes the work with the MICHTOX fate and transport submodel. This includes the evaluation of historical loading trends in the earlier project (Endicott, 2005). The preliminary modeling suggested that the scenario of historical PCB loads to the lake that best fit the available data was one in which loads increased from zero at a start date of 1940, peaked in 1961-1963, and then declined to present levels. This hindcast was later updated using the LM2-Toxic model, as described in Part 4.

A Bayesian Monte Carlo (BMC) uncertainty analysis was also conducted in the earlier project that demonstrated that MICHTOX predicted PCB concentrations should be within a factor of two of the measured data.

For the present study, atmospheric and tributary loads, including unmonitored tributary inputs, were calculated for the 1994-1995 LMMBP sampling period. The model was run using these inputs and the previously developed parameterization, and the applicability of MICHTOX as a screening model for predicting Lake Michigan total PCB concentrations in water, sediment, and fish was reconfirmed.

Chapter 4 summarizes the work with the MICHTOX food chain submodel and the application of the model for predicting potential total PCB concentrations under different loading scenarios. Data to parameterize the food chain model was obtained from the LMMBP sampling effort. The applicability of the food chain model was confirmed by applying it to the previous hindcast scenarios and to 1994-2000 Lake Michigan lake trout data.

MICHTOX was run for seven scenarios to help evaluate future loading trends and the impacts on PCB concentrations of various loading sources. These scenarios included:

- Continued loading at 1994-1995 levels
- Continued recovery - fast rate
- Continued recovery - slow rate
- Zero atmospheric deposition
- Zero tributary loads
- Zero atmospheric deposition and zero tributary loads
- Lake-wide sediment cleanup

The scenario model runs indicated that if declining trends in loading sources occurred at the faster of rates found in the scientific literature, the total PCB concentrations in an average 5-6 year-old lake trout in southern Lake Michigan would be reduced below the fish consumption advisory target level by approximately the year 2025. If loading sources declined at the slower rates found in the literature, total PCB concentrations in an average 5-6 year-old lake trout would be reduced below the target level by approximately 2053. The sensitivity scenarios indicated that the system was more affected by atmospheric vapor concentration and deposition than tributary loadings, and that the sediment reservoir of total PCBs played a large role in the concentrations observed in lake trout.

## References

Endicott, D.D. 2005. 2002 Lake Michigan Mass Balance Project: Modeling Total PCBs Using the MICHTOX Model. In: R. Rossmann (Ed.), MICHTOX: A Mass Balance and Bioaccumulation Model for Toxic Chemicals in Lake Michigan, Part 2. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, MED-Duluth, Large Lakes Research Station, Grosse Ile, Michigan. EPA/600/R-05/158, 140 pp.

Endicott, D.D., W.L. Richardson, and D.J. Kandt. 2005. 1992 MICHTOX: A Mass Balance and Bioaccumulation Model for Toxic Chemicals in Lake Michigan. In: R. Rossmann (Ed.), MICHTOX: A Mass Balance and Bioaccumulation Model for Toxic Chemicals in Lake Michigan, Part 1. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, MED-Duluth, Large Lakes Research Station, Grosse Ile, Michigan. EPA/600/R-05/158, 140 pp.